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SUPPLEMENTARY INFORMATION

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Supplementary Information

Rapid formation of a modern bedrock canyon by a single flood event

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Supplementary Background

Canyon Lake is a reservoir of the Guadalupe River in central Texas, USA (Fig. 1A), and regions within its drainage area received as much as 0.9 m of rainfall from June 30th to July 6th, 2002 (U.S. National Oceanographic and Atmospheric Administration). Due to heightened lake levels, Canyon Lake overflowed from July 4th to August 10th, 2002, into an emergency spillway designed by the U.S. Army Corps of Engineers to prevent dam failure. The largest spillway discharges lasted for three days and the daily-average discharge peaked on July 6th at 1461 m^3/s (U.S. Geological Survey Gage 08167800). The flood transformed the valley used as a spillway into a deeply incised bedrock gorge in a matter of days. It caused substantial damage to communities downstream of the dam resulting in a declared Federal Disaster Area: twelve people died, forty eight thousand homes were evacuated, and damage exceeded one billion dollars[S1].

Large dam-break[S2] and overflow floods (e.g., Tuttle Creek Lake, Kansas) have occurred elsewhere in recent times, but, to our knowledge, Canyon Lake Gorge is a rare

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Supplementary Methods

Abrasion Marks

Several linear abrasion marks or striations are evident in the canyon (Fig. S1) and in general are oriented flow parallel (Fig. 1B, Table S1). Abrasion does not appear to have been significant in eroding the limestone bedrock in the upper part of the gorge owing to the preservation of bedding surfaces there (Fig. S2).

Particle Size Measurements

To estimate the median particle size for the incipient motion calculations, we made point count of sediment within a boulder bar at 0.15 km < x < 0.25 km. The intermediate diameters of 100 particles were measured where they intersected a 1 m x 1 m grid[S3]. The distributions are given in Fig. S3 and the median particle sizes was 0.65 m. A similar method was used to estimate the median diameter of particles deposited along the canyon rim, but this time a grid spacing of ~ 0.2 m was used, yielding a median size of 0.05 m (Fig. S3, Table S2).

We also made 100 point count measurements of limestone boulders in the thalweg of the lower reach of the canyon (x = 2.0 km, Fig. 1B, Table S2) using a 1 m x 1 m grid, and found a median size of 0.33 m. For the flow duration calculations, we averaged this size and the size obtained from the boulders in the upper reach to estimate a representative size for erosion of the entire canyon (i.e., 0.49 m). Much of the sediment that was eroded from the canyon was deposited in a large mouth bar in the Guadalupe River. This material was excavated by the U.S. Army Corps of Engineers and dumped

on the terrace north of the mouth of the gorge. Although a statistical count of the particle sizes of this material was not performed, visual inspection indicated that sizes were similar to those measured within the canyon (i.e., ~ 0.5 m). Moreover, this size range is consistent with the average bed thickness of the Glen Rose Formation exposed in the gorge of 0.75 $\pm$ 0.5 m[S4].

Personal communication, Nov. 2009

Local residents Mark Hamilton, Joe Kerr and Ursula Kerr witnessed the flood event. Based on their visual estimates from exposed bedrock and water levels, as well as noise associated with boulder transport, they each independently estimated that most erosion occurred in about the first three to four days flooding, from 7/4/2002 to 7/8/2002.

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Supplementary Figures

Fig. S1. Example of scour marks along a bedding plane in the upper reach of the gorge. The pencil is 12 cm and points in the direction of flow.

Fig. S2. Preserved Cretaceous ripple forms along a bedding plane in the upper reach of the gorge.

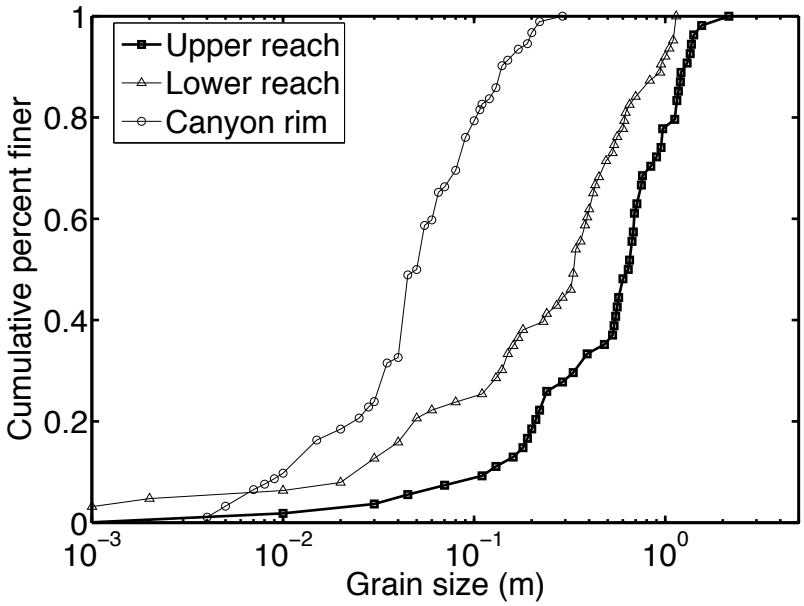

Fig. S3. Cumulative grain size distributions for the three point counts.

Supplementary Tables

Table S1. Location and orientation of scour marks.

	UTM Coordinates		Orientation
	North	West	degrees
Abrasion Mark 1	578337	3303708	95
Abrasion Mark 2	578238	3303663	60
Abrasion Mark 3	578162	3303629	10
Abrasion Mark 4	578106	3303486	37
Abrasion Mark 5	577845	3303302	45

Table S2: Location and median particle measured by point count in the upper reach, lower reach and above the canyon rim.

	UTM Coordinates		Diameter (m)
Point count upper reach	577676	3303242	0.65
Point count lower reach	579204	3303604	0.33
Point count canyon rim	578256	3303627	0.05

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Supplementary References

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